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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION DIVISION
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OFFICE OF
RESEARCH AND DEVELOPMENT

November 6, 2013

MEMORANDUM

SUBJECT: Review of the Documents for the Former Solutia, Inc., J.F. Queeny Plant Site (13-RC07-004)

FROM: David S. Burden, Ph.D., Director
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TO: Bruce Morrison
RCRA Corrective Action Project Manager
U.S. EPA Region 7

In response to your request, EPA's Ground Water Technical Support Center has completed a technical review of two documents for the Former Solutia, Inc., J. F. Queeny Plant Site, St. Louis, MO (the Site). The documents reviewed included:

(1) *Annual Baseline Groundwater Monitoring Report, Former Solutia Queeny Plant, St. Louis, Missouri, Volume I – Text, Tables, Graphs, and Figures, November 30, 2012, Rev 1 March 27, 2013* (the Report), prepared for SWH Investments II by Environmental Consulting & Remediation, Demolition, & Geotechnical Engineering.

(2) *Basçline Groundwater Monitoring Plan, Former Solutia Queeny Plant, St. Louis, Missouri, October 6, 2010* (the 2010 Plan), prepared for SWH Investments II by Environmental Operations, Inc.

The review was conducted under my direction, by Dr. Bruce Pivetz (hydrogeologist) and Dr. Daniel Pope (microbiologist) of the Dynamac Coproration, a contractor to EPA's Ground Water and Ecosystems Restoration Division. I have reviewed the comments below and concur with them. If you have any questions, please contact me at your convenience.

INTRODUCTION

The purpose of the scientific review of the reagent injection data in the Report is to determine "if the injections of amendments are a worthwhile approach" or if the potentially responsible parties (PRPs) should be taking a different approach to remediation of the ground-water contaminants at the Site. Oxidants and other reagents (RegenOx™, ORC Advanced™, and 3D Microemulsion with BioDechlor Inoculum [BDI®], all products from Regenesis Corporation of San Clemente, CA) are being injected to oxidize and biodegrade ground-water contaminants, including chlorobenzene, benzene, toluene, and tetrachloroethene (PCE) .

SUMMARY AND RECOMMENDATIONS

The reviewers determined that injection of the chemical oxidation reagents appears to have contributed to dissolved-phase contaminant reduction in groundwater at the Site. The reviewers believe that additional oxidant injections will be necessary to reduce total (sorbed- and dissolved-phase, and possibly non-aqueous phase liquid [NAPL]) contaminant mass in order to achieve site-specific remedial goals.

The contaminant data (i.e., parent and daughter compounds data) indicate that contaminant biodegradation has been taking place in the past at the locations where injections were made to enhance bioremediation. Due to the variability of the contaminant and geochemistry data presented in the Report, it is difficult to determine from the data presented in the two documents the degree of influence the injection of the biostimulating reagents (3D Microemulsion with BioDechlor Inoculum) may have on current biodegradation of contaminants. However, the data do indicate that the biostimulation approach is likely to be useful to reduce ground-water concentrations of the contaminants. The reviewers believe that additional biostimulation injections will be necessary to reduce total contaminant mass in order to achieve site-specific remedial goals. A more rigorous and robust evaluation of soil, ground-water, and hydrogeologic data will be necessary to sufficiently support any conclusions that sufficient remediation is occurring.

Recommendations are summarized below. Following these recommendations can provide additional support for the interpretations and conclusions presented in the Report, or may indicate that the interpretations and conclusions may need to be re-evaluated. The rationale for making these recommendations is discussed further in the General Comments and Specific Comments.

1. It is recommended to continue injection of oxidant amendments to achieve further contaminant mass reduction at the Site. Continued injection of biostimulating reagents is also recommended to help establish and maintain the strongly reducing geochemical conditions suitable for reductive dechlorination of the contaminants.

2. The reviewers recommend clarification of the well identification numbers, locations, depths, and position of the screened interval relative to its intended stratigraphic unit(s).

3. Compilation and evaluation of information for all wells mentioned in the text and/or shown on the figures is recommended. The boring logs should be used to construct cross sections that show each monitoring well with the stratigraphy, well screen position, low-flow pump position within the screen, and contaminant concentrations for each sampling event. These cross sections will strengthen or refine the conceptual site model and the understanding of contaminant migration pathways.

4. Continued quarterly ground-water monitoring should be conducted for all the wells for at least another year or two, to determine if there is rebound of contaminant concentrations as contaminants are slowly desorbed.

5. It is recommended that performance monitoring for the in-situ chemical oxidation and biostimulation effort should include sampling of the subsurface saturated soils (and/or continuous logging of the contaminant depths and relative levels of contaminants using a tool such as a Membrane Interface Probe [MIP]).

GENERAL COMMENTS

1. The ground-water monitoring data in the Report are currently inadequate to allow a satisfactory evaluation of the performance of the oxidant injections in terms of overall remediation of the subsurface (i.e., soil and ground water). It is very likely that some degradation of contaminant mass, and possibly redistribution of contamination, has occurred due to the oxidant injections. However, the extent and permanence of the contaminant mass reduction cannot be satisfactorily determined with the data presented in the Report.

2. Additional chemical oxidant injections will almost certainly be necessary to approach achievement of the remedial goals. The injected oxidant is able to degrade a wide variety of contaminants; however, for some of the less common Site-specific contaminants there may not currently be sufficient research presented in the literature, or practical experience, to be fully confident of the efficacy of *in-situ* chemical oxidation for those less common contaminants. The continuation of oxidant injection, however, should be coupled with a more robust evaluation of its performance (as discussed in the Recommendations and below in numerous comments). The Report presents conclusions and recommendations, which include an evaluation for additional treatment. This is a prudent step.

3. There is significant variability in contaminant concentration changes among all the monitoring wells near the oxidant injection locations. This reflects the probable variability in contaminant source mass in different locations, the complexity and variability in ground-water and contaminant flow paths, the complex and most likely incomplete distribution of the chemical oxidant, the relatively sparse temporal monitoring well data, and the relatively short time

between the oxidant injections and the June 2012 ground-water monitoring. These problems, which also apply to the biostimulation injections, make it difficult to conclude that there is a sufficiently broad general trend at all well locations that would lend assurance to the interpretation that the entire Site is being sufficiently remediated.

The variability of the contaminant and geochemistry data also makes it difficult to determine the influence of the injection of the biostimulating reagents on any current biodegradation of contaminants. For example, at OBW-2 where the biostimulation reagents were injected, the 2011 samplings (pre-injection) showed the chlorinated solvent parent and daughter compounds at nondetect levels, but the post-injection samplings in 2012 showed high dissolved concentrations of parent and daughter compounds. At the REC-4 biostimulation area, the relatively rapid changes in contaminant concentrations noted (2-3 orders of magnitude change) from the 9/6/2011 sampling event to the 12/20/2011sampling event indicate that the situation is probably complicated by the presence of NAPL, making attribution of contaminant changes to biodegradation problematic.

4. The Report has confusing presentations, incomplete information, and some discrepancies regarding numbers, locations, and specifications of the monitoring wells. Some wells are mentioned in the text that do not appear in Table 1 or on the figures. The table in Section 3.1 of the 2010 Plan has a useful and clear format that lists the monitoring area, the monitoring location ID, and the location criteria. Including a table such as that table in the 2010 Plan would help make future Monitoring Reports clearer and more useful.

5. The Report includes two plan view maps of the monitoring wells locations (one map for the fill/silty clay units and one map for the sand/bedrock units), combined with "baseline" and recent dissolved contaminant data. It also includes graphs of contaminant concentrations with time in a number of monitoring wells. These items are necessary; however, there is no visualization of the vertical subsurface characteristics, such as the stratigraphy of the different units (with depths, elevations, well information, and correlations between wells). Cross sections showing the stratigraphy and the depths of the wells would be extremely useful for presenting and aiding continual refinement of the conceptual site model. A better visual presentation of the available hydrogeological and contaminant data in the vertical direction will facilitate the reviewer and others who read the Report in interpretation of the ground-water and contaminant migration pathways and behavior.

6. Monitoring of ground water and the dissolved-phase contaminant concentrations is important in regard to concentration-based remedial goals. It also allows a time-series of concentration data at a given monitoring location. The concentration data can be used to determine when the dissolved contamination remedial goal appears to be met; however, the data provided are not sufficient to conclude that sufficient subsurface remediation and contaminant mass reduction has occurred, especially at sites where there may be a residual non-aqueous liquid phase (NAPL). After oxidant injection, slow desorption of sorbed or residual contaminants will occur, and dissolved-phase concentrations will increase (i.e., "rebound"). The possibility of rebound is mentioned in the text, but is not adequately addressed.

The majority of the contaminant mass in source areas is likely to be in sorbed or residual form (i.e., not dissolved in ground water). This contaminant mass will serve as a continuing source to ground water. Contaminant concentrations in ground water can range widely even though the total contaminant mass in the soil/ground water system may change relatively little. Therefore it is important to sample and track the total contaminant mass in the various compartments of the subsurface system (i.e., not just in ground water) in order to understand and assess remediation progress.

Since the oxidant used was RegenOx (developed by Regenesis), it is useful to cite some discussions from a Regenesis publication in which Regenesis emphasizes the necessity for soil samples or logging (in addition to ground-water sampling) in order to understand total contaminant mass loss:

> "*The verification that mass has been reduced is found by taking a significant number of soil samples or using advance* [sic] *techniques, like Membrane Interphase* [sic; Interface] *Probes (MIPs), to map the subsurface concentration of contaminants. Monitoring the concentrations in the groundwater alone speaks only to the aqueous phase, ignoring the soil bound and generally greatest mass of contaminant.*" (Section 5.3.2 Treatment of Residual/Sorbed NAPL; page 29)

and

> "*After the injection, treatment progress should be monitored by collecting groundwater and/or soil samples and analyzing the parameters discussed earlier in Section 7.0. The sampling frequency is dictated by the anticipated half-lives of the contaminants, but generally varies from weekly to monthly. It is important to recognize that sufficient time is required to evaluate conditions after the site reaches a new, post-treatment equilibrium.*" (Section 9.4 Post-Treatment Performance Monitoring; page 53)

The reviewers recommend ground water and soil samples, taken in sampling events over several years, in order to properly understand the reduction in contaminant mass effected by the reagent injections.

SPECIFIC COMMENTS

1. Section 1.1. Without knowing what other remedial activities have occurred (in addition to the injections for ground-water remediation) it is not possible to evaluate if those other activities could have contributed to the contaminant concentration changes attributed to the injections. For this review, not knowing what other remedial activities have occurred increases the uncertainty associated with interpreting the data presented in the Report for assessing injection performance.

2. Section 4.3.5. The concept that the ground water in the fill and silty clay connects with the underlying sand (and/or the bedrock), rather than directly with the Mississippi River, is plausible.

The higher potentiometric heads in the fill and silty clay suggest a downward direction of ground-water flow. The next paragraph of the Report, however, states that the sand unit is confined. The sand unit would not be completely confined if there is either ground-water flow or leakage from the silty clay to the sand. It is more likely to be a leaky confined unit.

This complicates the apparent current conceptual site model that ground water and dissolved contamination move downward through the silty clay to the bedrock in the central area of the Site where the sand is absent, and then horizontally or upward into the sand. While this flow most likely occurs, it is also probable that dissolved contamination could move downward from the silty clay into the sand in a number of other locations throughout the Site.

3. Section 4.3.5. Wells MW-2R, MW-8R, MW-13R, MW-21R, and MW-8B are not listed in Table 1. It is recommended that information about these wells (e.g., depths and screened intervals) be added to Table 1, so that the relationship between these wells and their associated bedrock or sand wells can be understood and used in evaluating ground-water flow directions.

Further, seven bedrock wells are listed here; whereas, previous text said that there were three wells screened in bedrock. Perhaps the other four wells are screened in both bedrock and sand (or silty clay). Since the specifications for these wells are not available in Table 1, this review cannot fully evaluate the hydrogeologic interpretations in the text.

4. Section 4.3.5. MW-2B appears to be in the northwestern portion of the Site (as shown on Figures 3 to 10). However, this paragraph states that it is associated with well MW-2R, located along the eastern perimeter of the Site. The reviewers recommend clarification of this apparent discrepancy so that the correct spatial relationships can be used in evaluating ground-water flow directions.

Further, in Table 1, MW-2B is listed as a Fill/Silty Clay Well; however, this first bullet states that MW-2B is screened in the sand.

5. Section 5.2.1. Neither Table 2 nor any of the text indicates if the injection occurred using a bottom-up or a top-down injection strategy. It is important to know the injection strategy because a top-down injection strategy is more likely to deliver the reagents at the target interval. With any injection strategy, the injected reagents may move from the injection probe into lengths of the probe hole away from the injection probe, and enter the formation at locations other than the target interval (i.e., the formation interval directly adjacent to the injection probe). If top-down injection is used, there is no probe hole below the injection probe, so the likelihood of missing the target interval is lessened. With bottom-up injection, the injected reagents may enter the subsurface at any depth of the probe hole below the injection probe (especially into intervals that are more permeable than the target interval) and perhaps not at the intended target depth interval. This problem of undesired placement of the reagent is especially likely with thick total target injection intervals, as the possibility is greater that there will more permeable layers than the target interval.

Therefore, it is recommended to specify the injection strategy in order to assess the likelihood that the injected reagents were actually delivered to their intended target interval.

6. Section 7. It is not clear how well the source areas have been identified and characterized. In several of the sections on data trends the Report indicates some uncertainty about source areas. Additional characterization may be needed if there are future unexpected anomalies in contaminant concentrations.

7. Section 7.3. The physical movement of source materials and the occurrence of desorption (both of which are due to injection activities [as noted here in the Report]) complicates interpretation of ground-water data. This is another reason for conducting a rigorous and robust evaluation of the Site data.

8. The data in Table 4 (TABLE 4 FF AREA WELLS NATURAL ATTENUATION PARAMETERS) indicate that several of the sampling locations in the area where biostimulation reagent injections were made have relatively low Total Organic Carbon (TOC) values. This may indicate that the reagents were not uniformly distributed in the subsurface, or perhaps were degraded before reaching the sampling locations. Direct-push sampling on a grid may be useful to monitor and tweak reagent injection approaches.

REFERENCES

Regenesis. 2005. Principles of Chemical Oxidation Technology for the Remediation of Groundwater and Soil, Version 1.06, RegenOx Design and Application Manual.

cc: Michael Fitzpatrick, 5303P
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